High Performance Enclosure Details

Dr John Straube, P.Eng.
Dept. of Civil Engineering / School of Architecture
University of Waterloo
Building Science Corporation

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Learning Objectives

- *Apply concepts of separating interior and exterior environments to increase enclosure functionality*
- *Choose from various design approaches to create a high performance*
- *Identify design parameters and situations that have been successfully addressed in examples presented*
- *Recommend to clients the advantages and techniques available in designing high-performance enclosures*

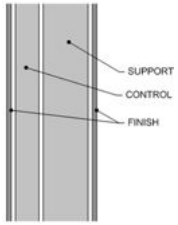
The Devil is in the Details

- Targets and codes have raised awareness
- People “know” you need
  - Lots of insulation value
  - No thermal bridges
  - No air leaks
  - A drainage plane leading to flashing
- But, how to this?

Basic Functions of the Enclosure

- 1. Support
  - Resist and transfer physical forces from inside and out
- 2. Control
  - Control mass and energy flows
- 3. Finish
  - Interior and exterior surfaces for people
- Distribution – a building function

Functional Layers



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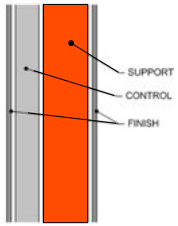
Basic Enclosure Functions

- **Support**
  - **Resist & transfer physical forces from inside and out**
    - Lateral (wind, earthquake)
    - Gravity (snow, dead, use)
    - Rheological (shrink, swell)
    - Impact, wear, abrasion
- Control
  - Control mass and energy flows
- Finish
  - Interior and exterior surfaces for people

Functional Layers



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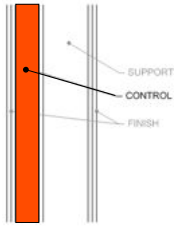
Enclosures No. 6 /

Basic Enclosure Functions

- Support
  - Resist & transfer physical forces from inside and out
- **Control**
  - **Control mass and energy flows**
    - **Rain** (and soil moisture)
      - Drainage plane, capillary break, etc.
    - **Air**
      - Continuous air barrier
    - **Heat**
      - Continuous layer of insulation
    - **Vapor**
      - Balance of wetting/drying
- Finish
  - Interior and exterior surfaces for people

Functional Layers



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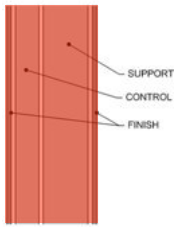
Enclosures No. 7 /

Other Control . . .

- Support
- **Control**
  - **Fire**
    - **Penetration**
    - **Propagation**
  - **Sound**
    - **Penetration**
    - **Reflection**
  - **Light**
    - **Diffuse/glare**
    - **View**
- Finish

Functional Layers



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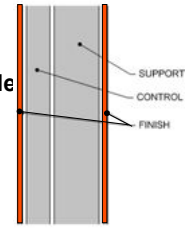
Enclosures No. 8 /

Basic Enclosure Functions

- Support
  - Resist & transfer physical forces from inside and out
- Control
  - Control mass and energy flows
- **Finish**
  - **Interior & exterior surfaces for people**
    - Color, speculance
    - Pattern, texture

Functional Layers



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History of Control Functions

- Older Buildings
  - One layer does everything
- Newer Building
  - Separate layers,
    . . . separate functions

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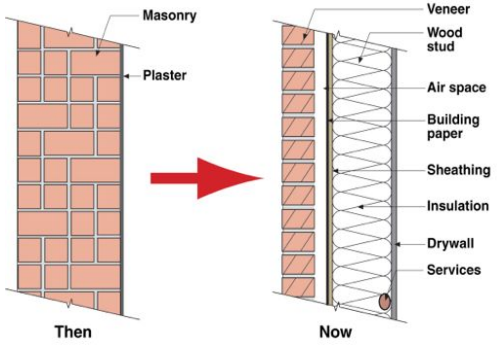
No. 10

Changes



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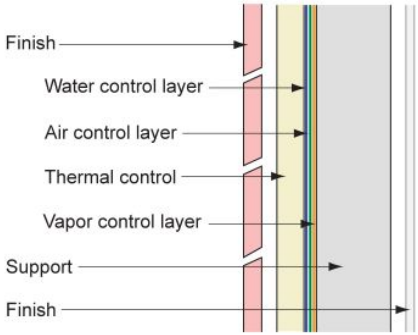
The "Perfect Wall"

- Finish of whatever
  - May need ventilated
- **Control continuity is the key**
  - Water: Drainage gap + drainage plane
  - Air: Air barrier
  - Heat: Insulation
  - Vapor: vapor barrier



What is a High-performance enclosure?

- One which provides high levels of control
- Poor *continuity* limits performance
- Poor continuity causes most problems too:
  - E.g. air leakage condensation
  - Rain leakage
  - Surface condensation
  - Cold windows
- This presentation: continuity + high levels

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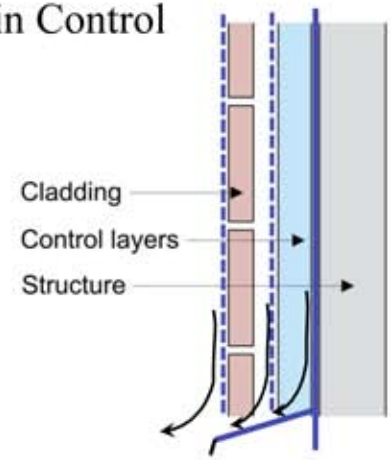
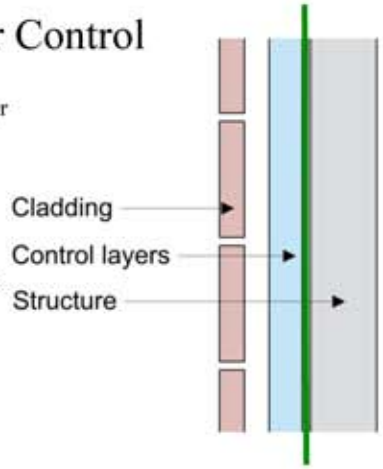
Rain Control

- Rain shedding
- Drainage
- Must integrate with flashing, drainholes
- Overlap everything
- No holes



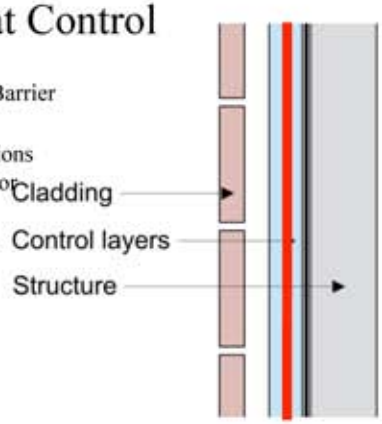
Air Control

- Continuous Air Barrier
  - Continuous
  - Stiff
  - Strong
  - Durable
  - Air Impermeable
- Only very small holes tolerable



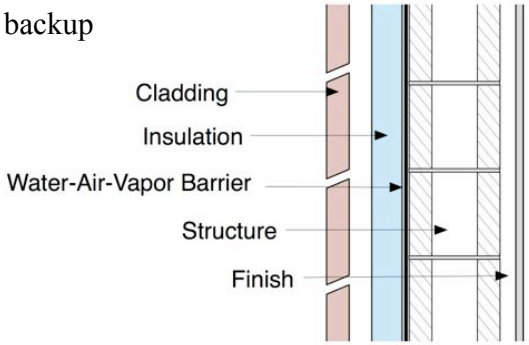
Heat Control

- Continuous Thermal Barrier
  - Even R10 is good
- Accept small penetrations as long as no comfort or durability issues
- Windows are a major concern
  - Heat loss/gain
  - Solar gain



Perfect Wall

- CMU backup



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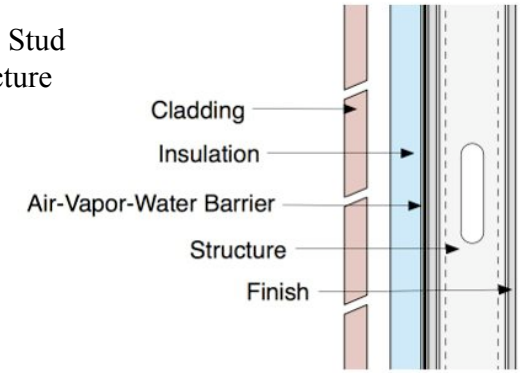
Perfect Wall

- Steel Stud Structure



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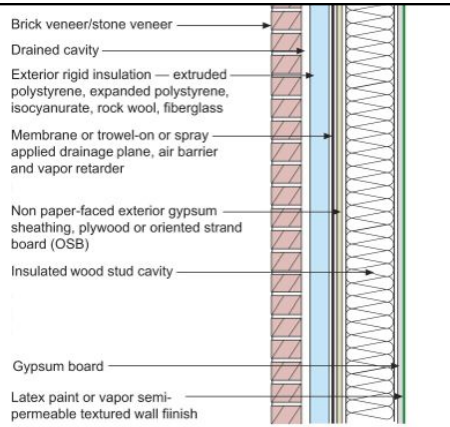
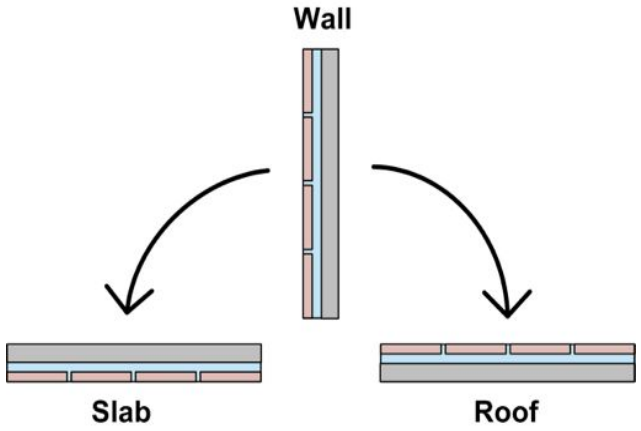

Brick veneer/stone veneer
Drained cavity
Exterior rigid insulation — extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass
Membrane or trowel-on or spray applied drainage plane, air barrier and vapor retarder
Non paper-faced exterior gypsum sheathing, plywood or oriented strand board (OSB)
Insulated wood stud cavity
Gypsum board
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile



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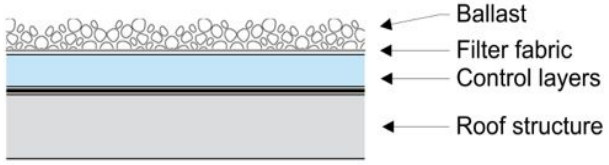

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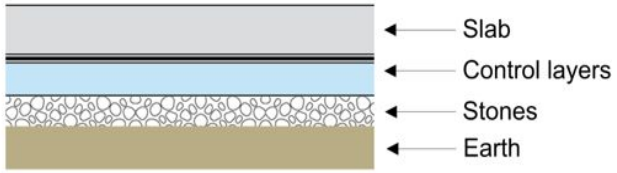

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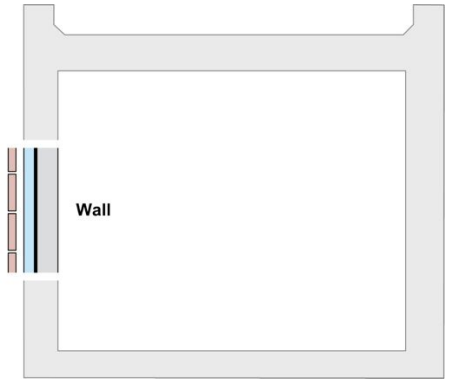

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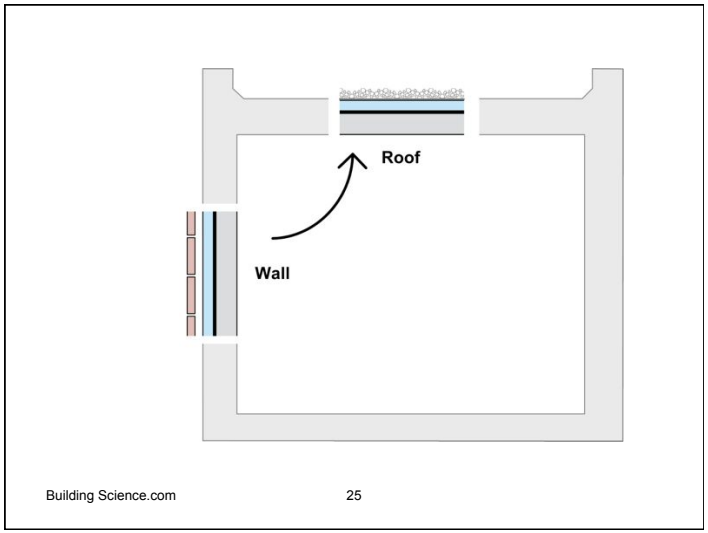
Roof
Wall
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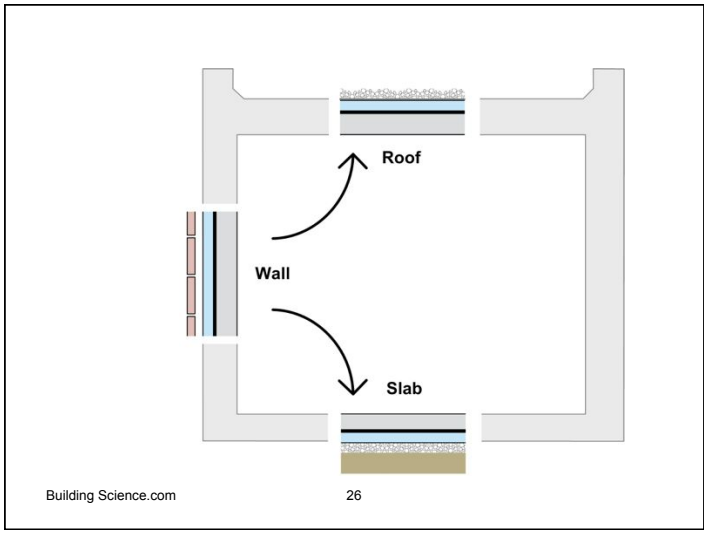
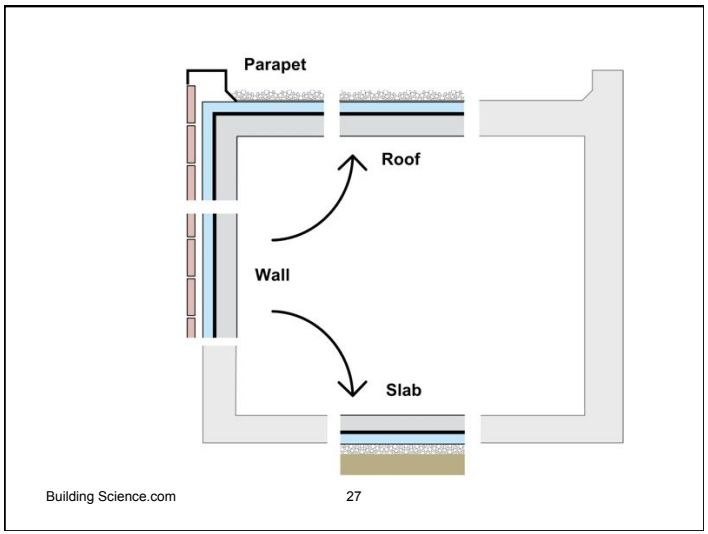
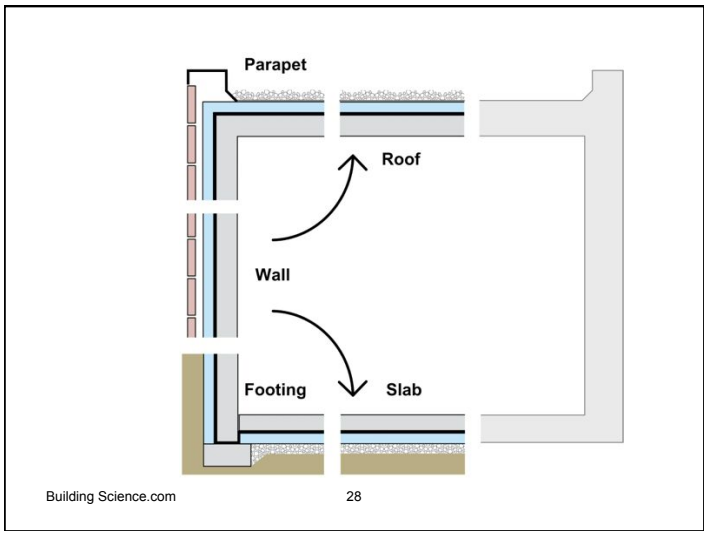
25


Roof
Wall
Slab
Building Science.com
26


Parapet
Roof
Wall
Slab
Building Science.com
27


Parapet
Roof
Wall
Footing
Slab
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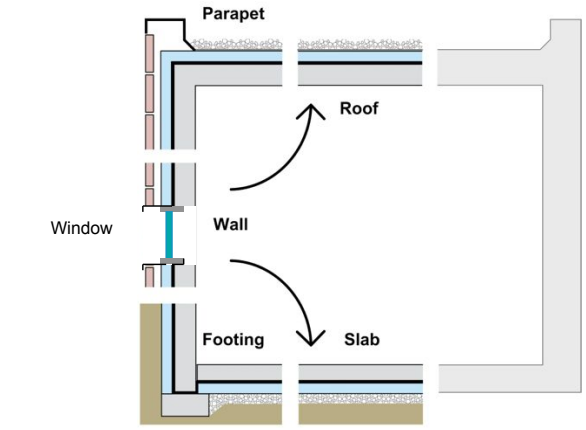
28



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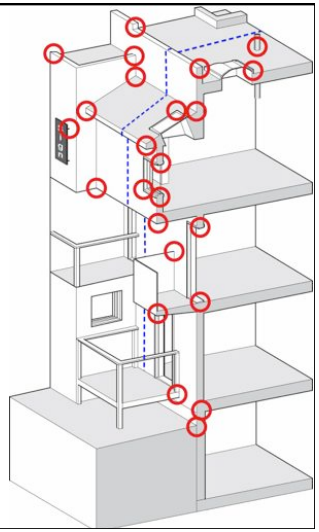
Enclosure Design: Details

- Details demand the same approach as the enclosure.
- Scaled drawings required at ◯

Details needed at:

- Change in *plane*
- Change in *material*
- Change in *trade*



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Details

- Need to trace continuity of
  - Structure (connections)
  - Water control
  - Air Control
  - Thermal control

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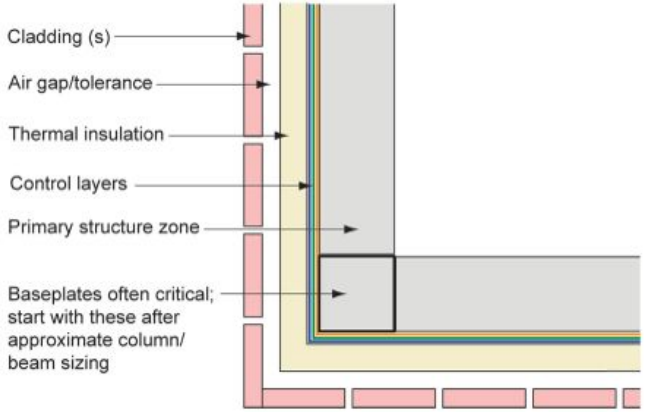
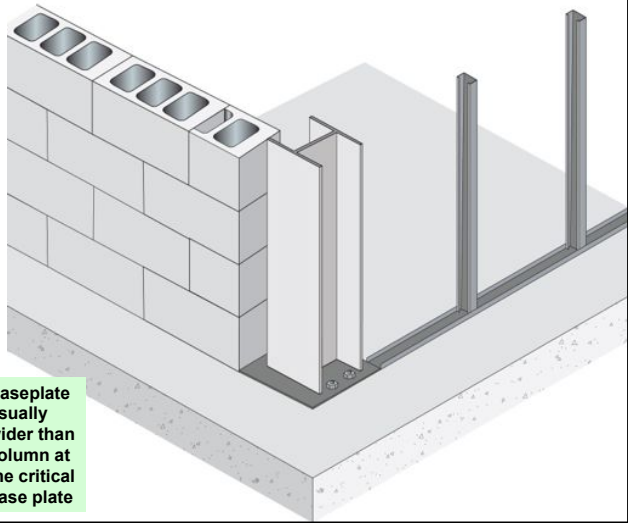
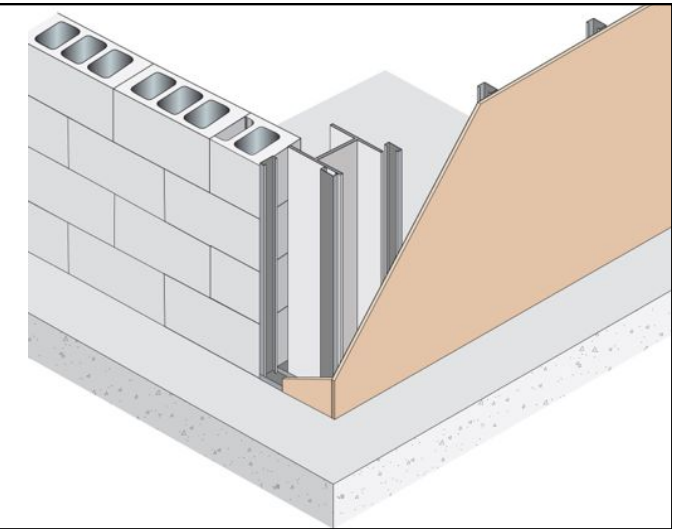
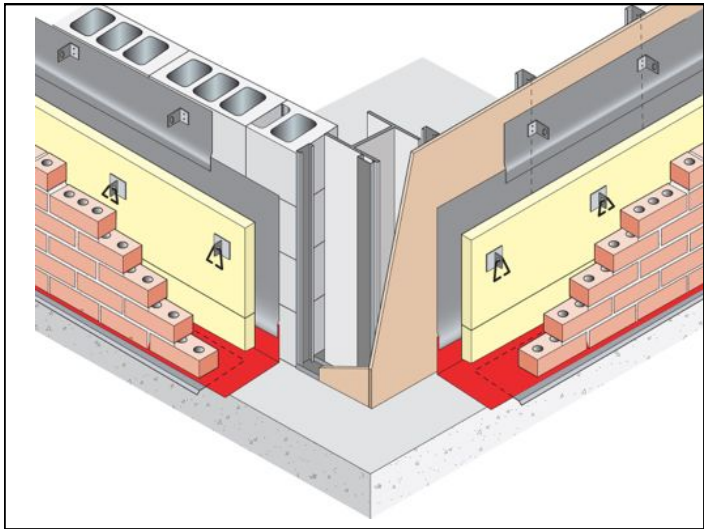
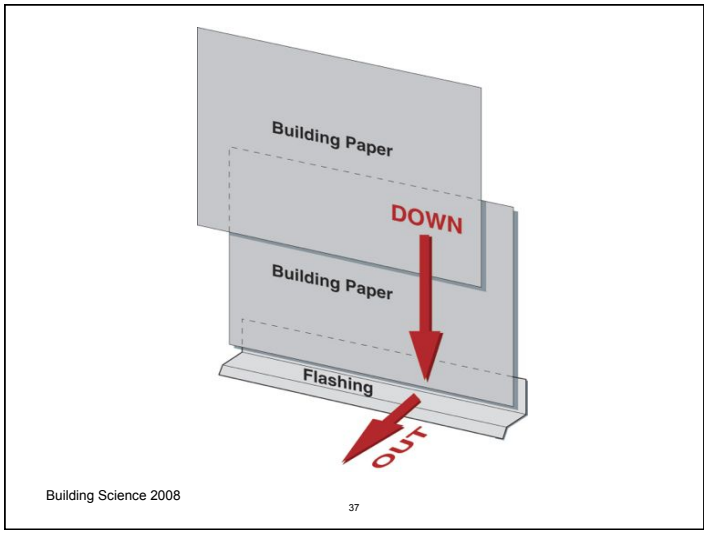
Commercial:Early stage planning










Building Paper
DOWN
Building Paper
Flashing
OUT
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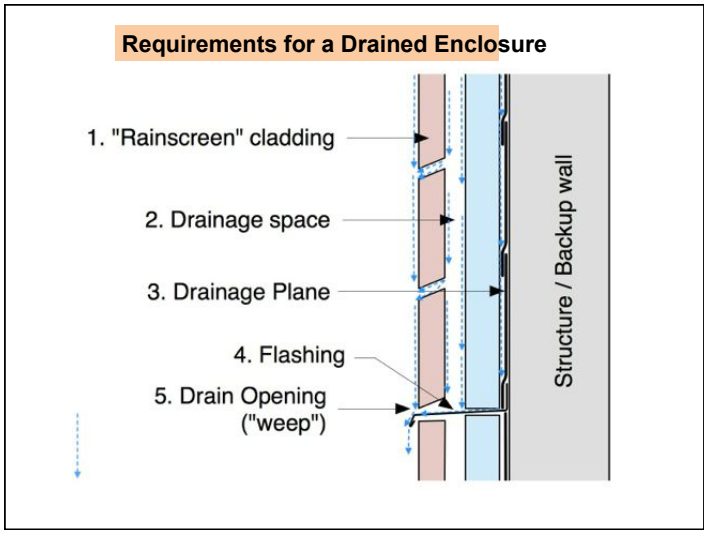
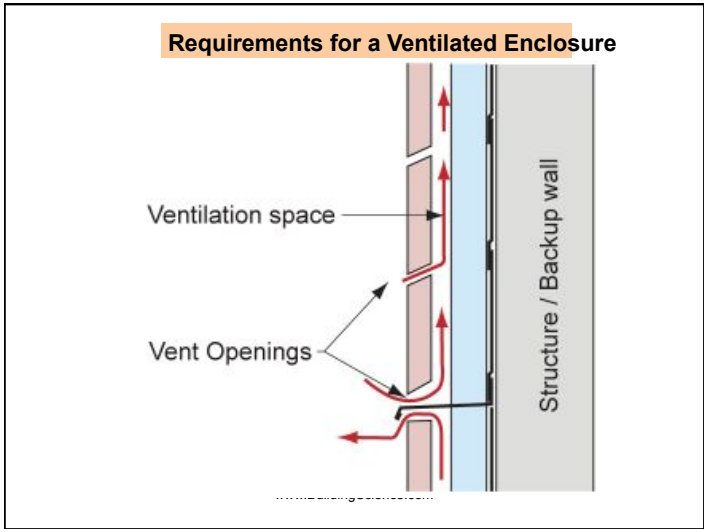
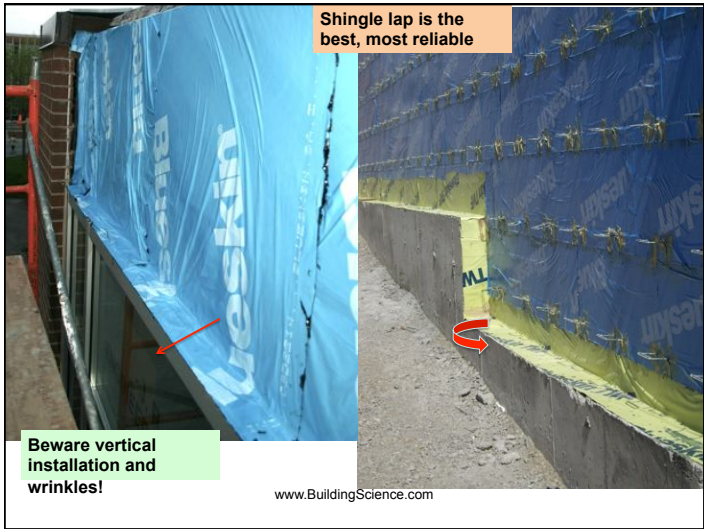
37


Requirements for a Drained Enclosure
1. "Rainscreen" cladding
2. Drainage space
3. Drainage Plane
4. Flashing
5. Drain Opening ("weep")
Structure / Backup wall


Requirements for a Ventilated Enclosure
Ventilation space
Vent Openings
Structure / Backup wall


Shingle lap is the best, most reliable
Beware vertical installation and wrinkles!
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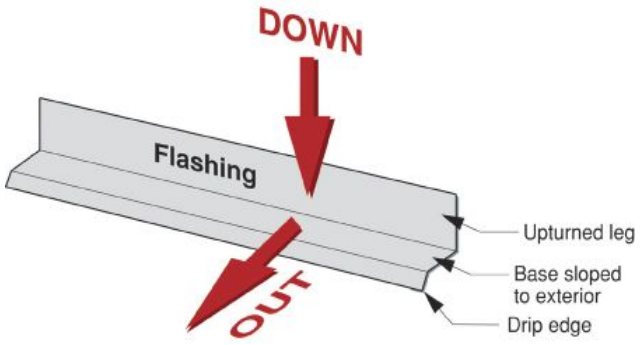
Flashing must be waterproof



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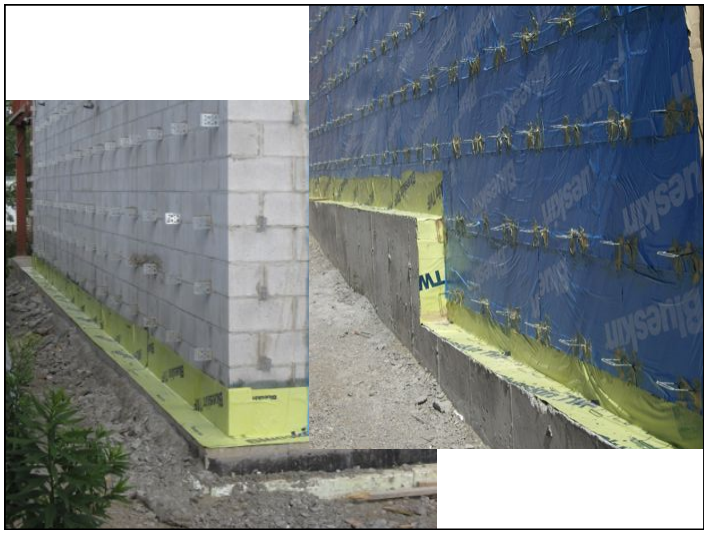
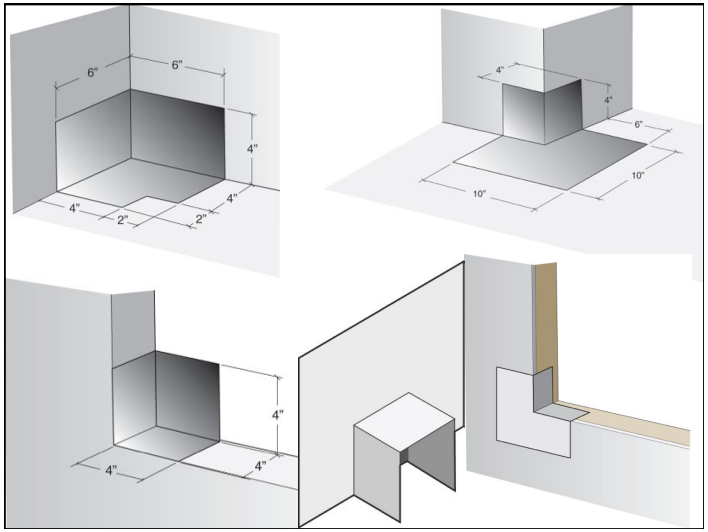
Joseph Lstiburek – Rain Control 41





Windows

- Finding the air-water-thermal layer can be challenging
- Usually, best air and water seal is inner edge
  - few chances for water leaks at corners
- Alu windows have thermal line at TB
  - Line up with thermal control in wall

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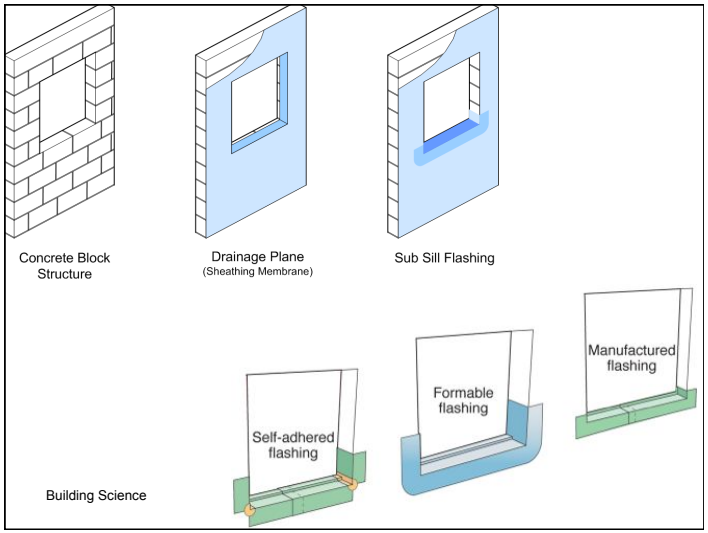
Leaky windows

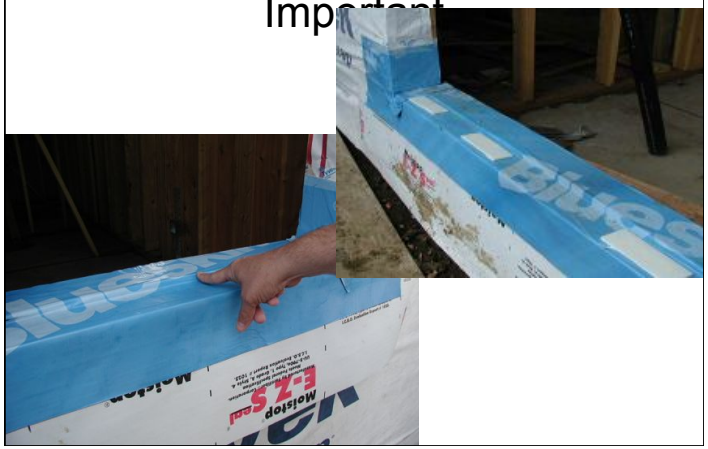
- Studs and sheathing are sensitive to leaks

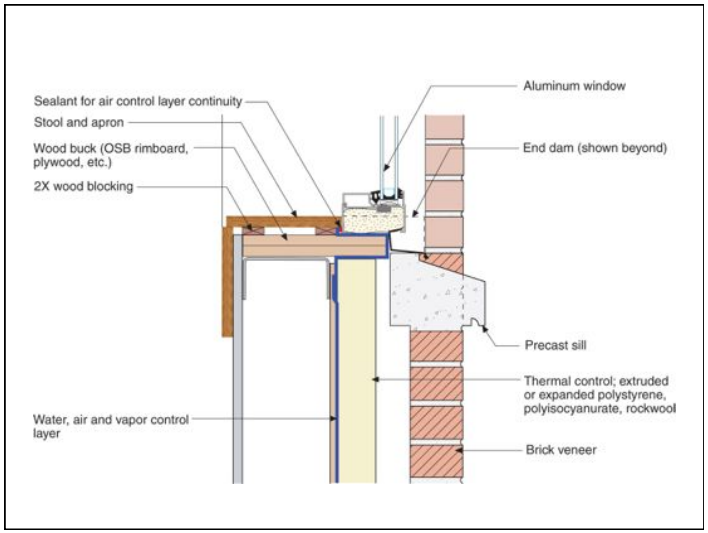


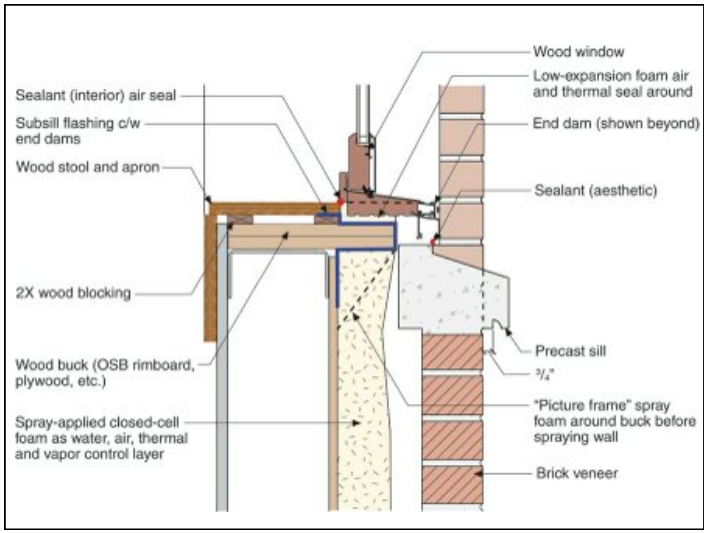
Mixed membrane + liquid

Often use membranes for transitions

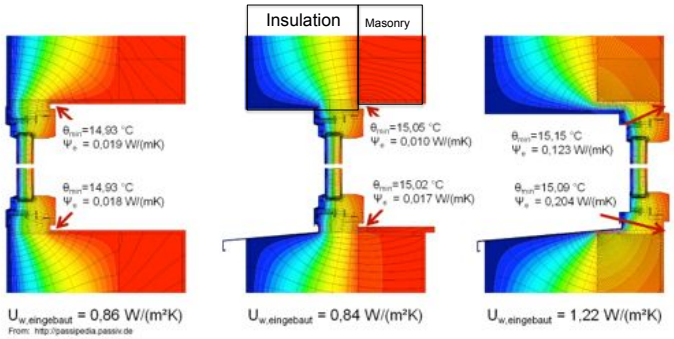
Backdams / Slopes are Important




Sealant for air control layer continuity
Stool and apron
Wood buck (OSB rimboard, plywood, etc.)
2X wood blocking
Water, air and vapor control layer
Aluminum window
End dam (shown beyond)
Precast sill
Thermal control; extruded or expanded polystyrene, polyisocyanurate, rockwool
Brick veneer


Sealant (interior) air seal
Subsill flashing c/w end dams
Wood stool and apron
2X wood blocking
Wood buck (OSB rimboard, plywood, etc.)
Spray-applied closed-cell foam as water, air, thermal and vapor control layer
Wood window
Low-expansion foam air and thermal seal around
End dam (shown beyond)
Sealant (aesthetic)
Precast sill
¾"
"Picture frame" spray foam around buck before spraying wall
Brick veneer

Window Location



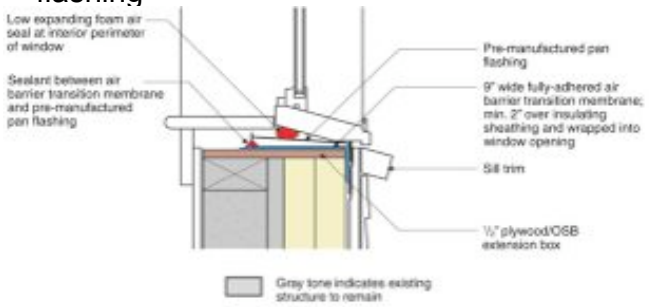
Outie Window
(but within thermal line)

Innie Window
(but within thermal line)

Innie Window
(inside of thermal line)

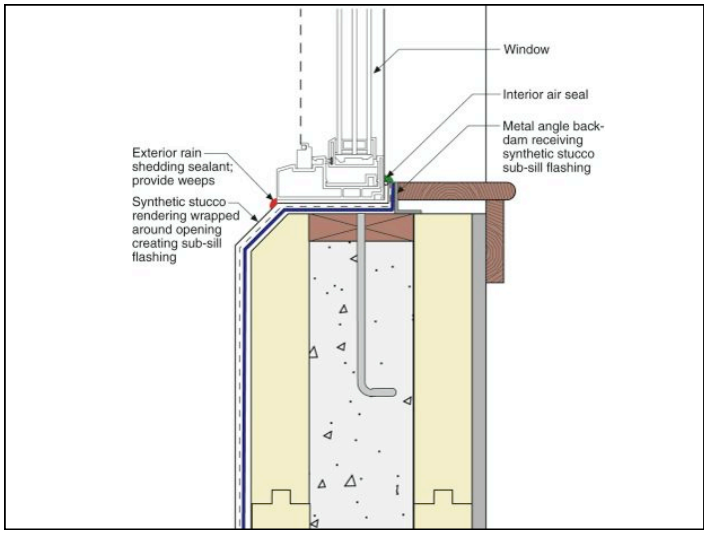
- Beware strap anchor air leakage

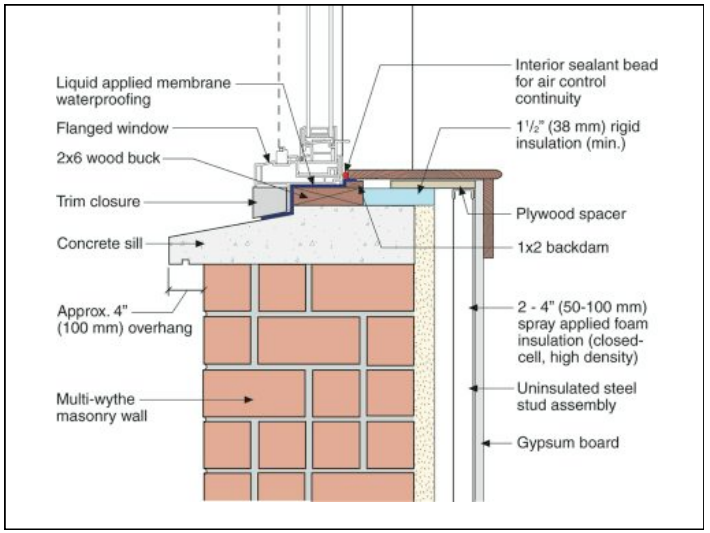
- Beware air leakage at premade sill flashing


Low expanding foam air seal at interior perimeter of window
Sealant between air barrier transition membrane and pre-manufactured pan flashing
Pre-manufactured pan flashing
9" wide fully-adhered air barrier transition membrane; min. 2" over insulating sheathing and wrapped into window opening
Sill trim
½" plywood/OSB extension box
Gray tone indicates existing structure to remain

- Beware thermal bridge of metal sill pans

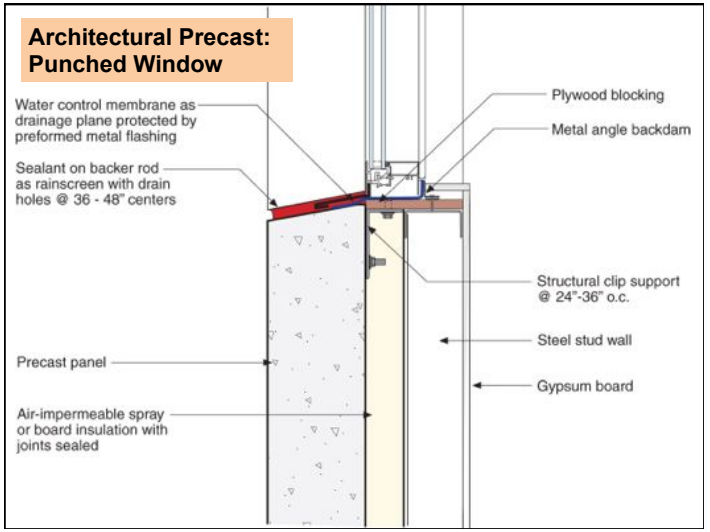
- Face of foam as air/water layer


Window
Interior air seal
Metal angle back-dam receiving synthetic stucco sub-sill flashing
Exterior rain shedding sealant; provide weeps
Synthetic stucco rendering wrapped around opening creating sub-sill flashing

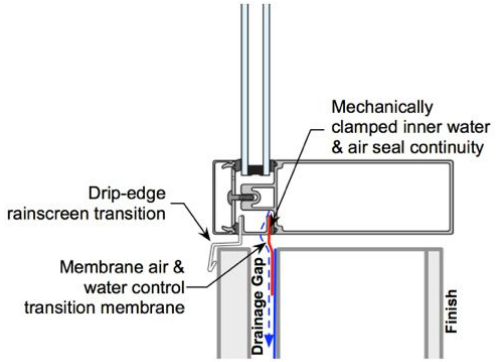

Liquid applied membrane waterproofing
Flanged window
2x6 wood buck
Trim closure
Concrete sill
Approx. 4" (100 mm) overhang
Multi-wythe masonry wall
Interior sealant bead for air control continuity
1½" (38 mm) rigid insulation (min.)
Plywood spacer
1x2 backdam
2 - 4" (50-100 mm) spray applied foam insulation (closed-cell, high density)
Uninsulated steel stud assembly
Gypsum board

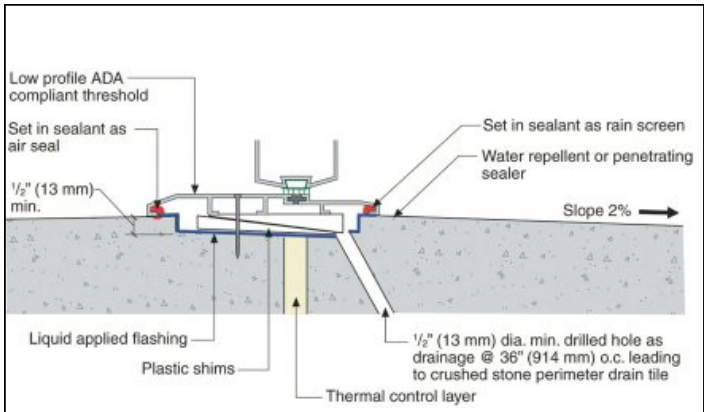
Continuous interior angle provides backdam and airseal continuity

Architectural Precast: Punched Window


Water control membrane as drainage plane protected by preformed metal flashing
Sealant on backer rod as rainscreen with drain holes @ 36 - 48" centers
Precast panel
Air-impermeable spray or board insulation with joints sealed
Plywood blocking
Metal angle backdam
Structural clip support @ 24"-36" o.c.
Steel stud wall
Gypsum board

Curtainwall Integration


Mechanically clamped inner water & air seal continuity
Drip-edge rainscreen transition
Membrane air & water control transition membrane
Drainage Gap
Finish


Low profile ADA compliant threshold
Set in sealant as air seal
½" (13 mm) min.
Set in sealant as rain screen
Water repellent or penetrating sealer
Slope 2%
Liquid applied flashing
Plastic shims
Thermal control layer
½" (13 mm) dia. min. drilled hole as drainage @ 36" (914 mm) o.c. leading to crushed stone perimeter drain tile

Roof-Wall

- Water control
  - sometimes overhangs, sometimes continuous
- Air control
  - Sometimes roof membrane, sometimes ceiling plane

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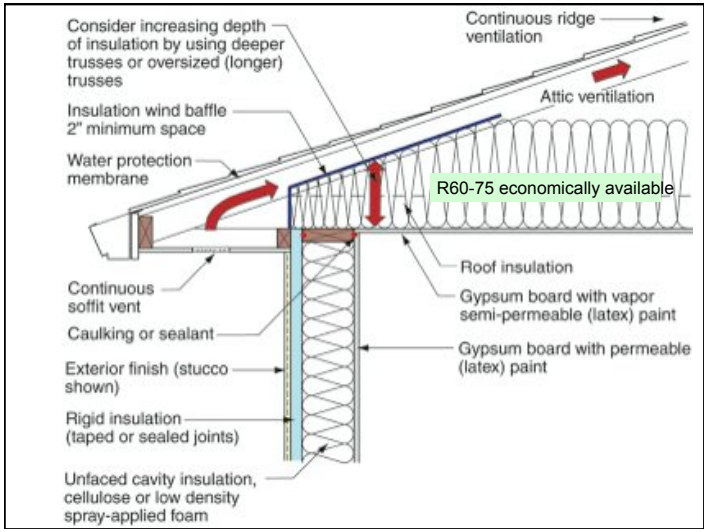
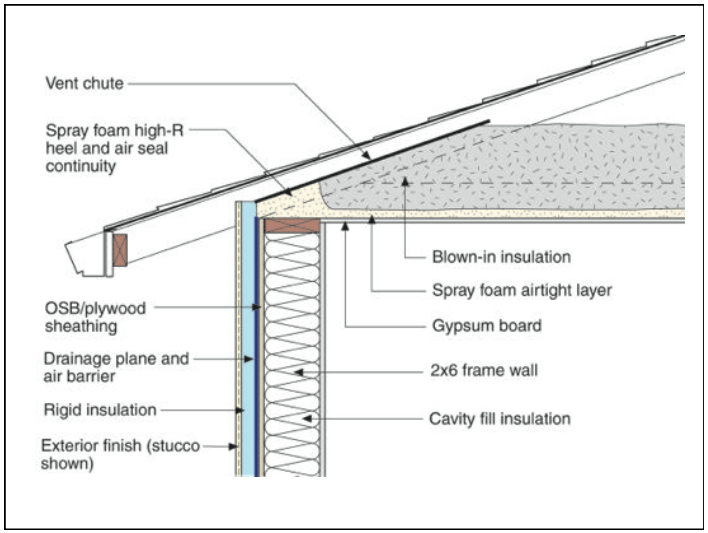
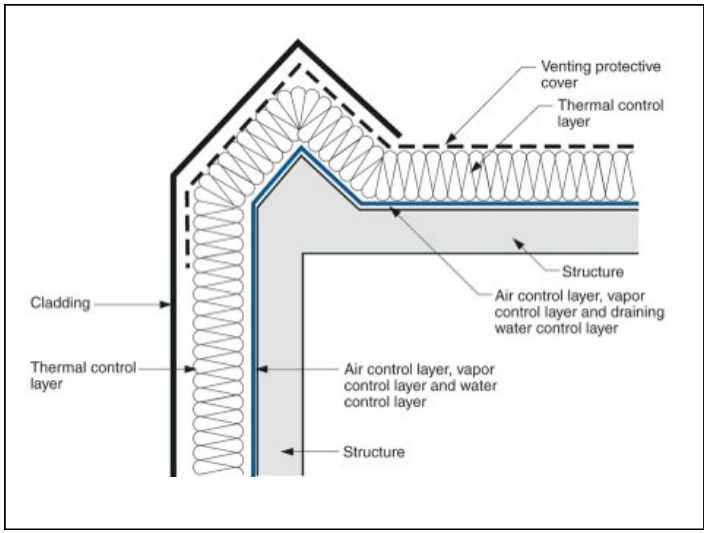
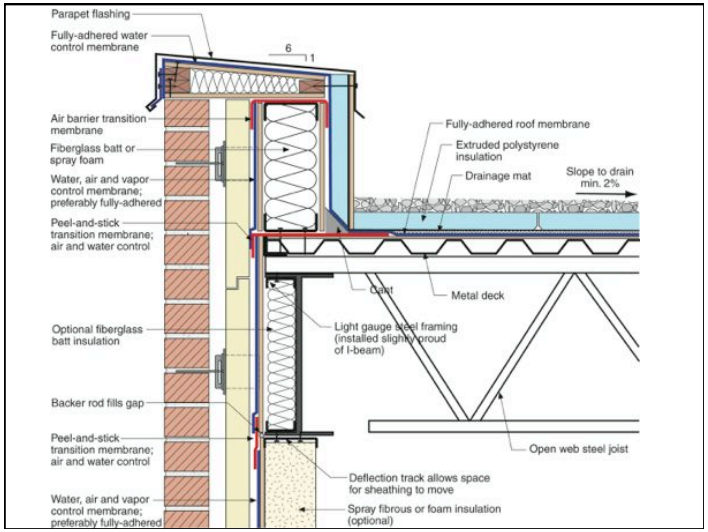
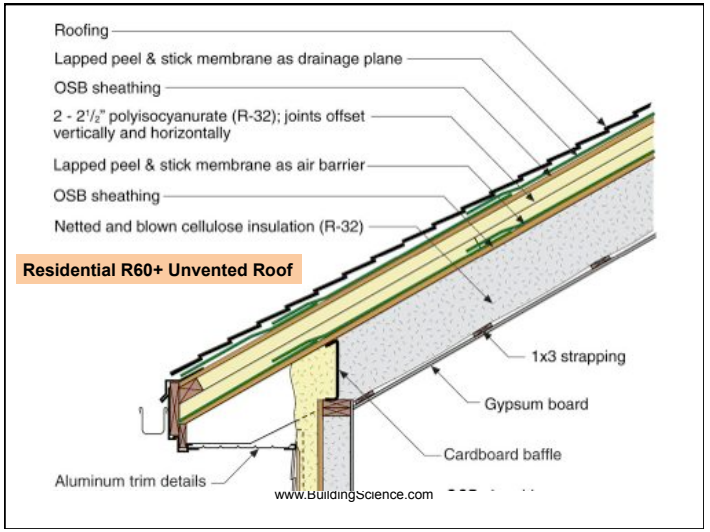

Consider increasing depth of insulation by using deeper trusses or oversized (longer) trusses
Continuous ridge ventilation
Attic ventilation
Insulation wind baffle 2" minimum space
Water protection membrane
R60-75 economically available
Roof insulation
Gypsum board with vapor semi-permeable (latex) paint
Continuous soffit vent
Caulking or sealant
Gypsum board with permeable (latex) paint
Exterior finish (stucco shown)
Rigid insulation (taped or sealed joints)
Unfaced cavity insulation, cellulose or low density spray-applied foam


Vent chute
Spray foam high-R heel and air seal continuity
Blown-in insulation
Spray foam airtight layer
OSB/plywood sheathing
Gypsum board
Drainage plane and air barrier
2x6 frame wall
Rigid insulation
Cavity fill insulation
Exterior finish (stucco shown)


Venting protective cover
Thermal control layer
Structure
Cladding
Air control layer, vapor control layer and draining water control layer
Thermal control layer
Air control layer, vapor control layer and water control layer
Structure


Parapet flashing
Fully-adhered water control membrane
6
1
Air barrier transition membrane
Fiberglass batt or spray foam
Water, air and vapor control membrane; preferably fully-adhered
Peel-and-stick transition membrane; air and water control
Fully-adhered roof membrane
Extruded polystyrene insulation
Drainage mat
Slope to drain min. 2%
Cant
Metal deck
Optional fiberglass batt insulation
Light gauge steel framing (installed slightly proud of I-beam)
Backer rod fills gap
Peel-and-stick transition membrane; air and water control
Open web steel joist
Deflection track allows space for sheathing to move
Water, air and vapor control membrane; preferably fully-adhered
Spray fibrous or foam insulation (optional)


Roofing
Lapped peel & stick membrane as drainage plane
OSB sheathing
2 - 2½" polyisocyanurate (R-32); joints offset vertically and horizontally
Lapped peel & stick membrane as air barrier
OSB sheathing
Netted and blown cellulose insulation (R-32)
Residential R60+ Unvented Roof
1x3 strapping
Gypsum board
Cardboard baffle
Aluminum trim details
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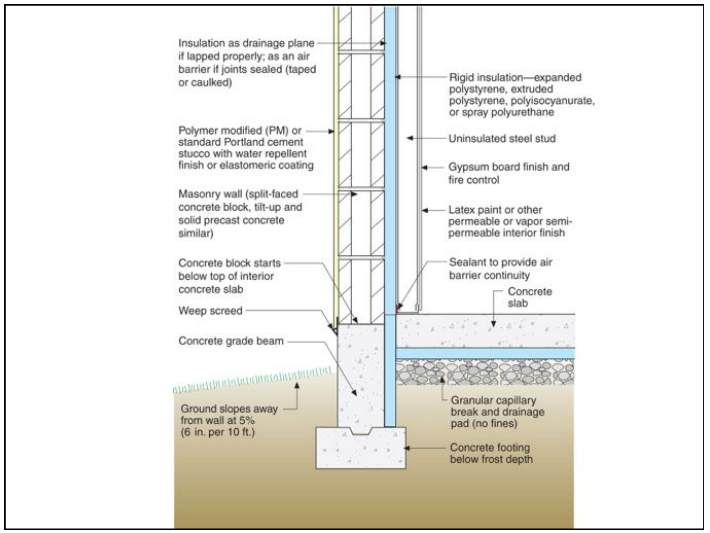
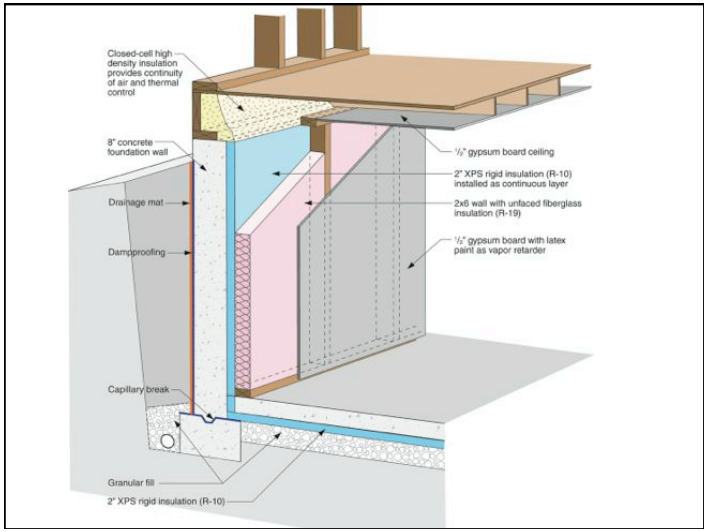
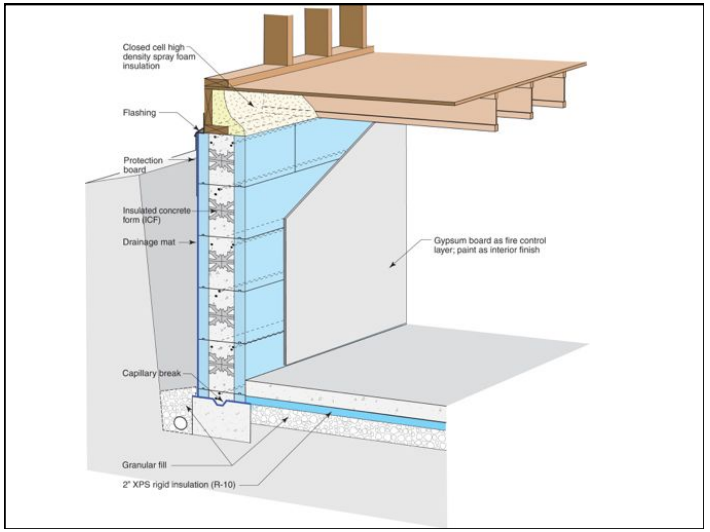
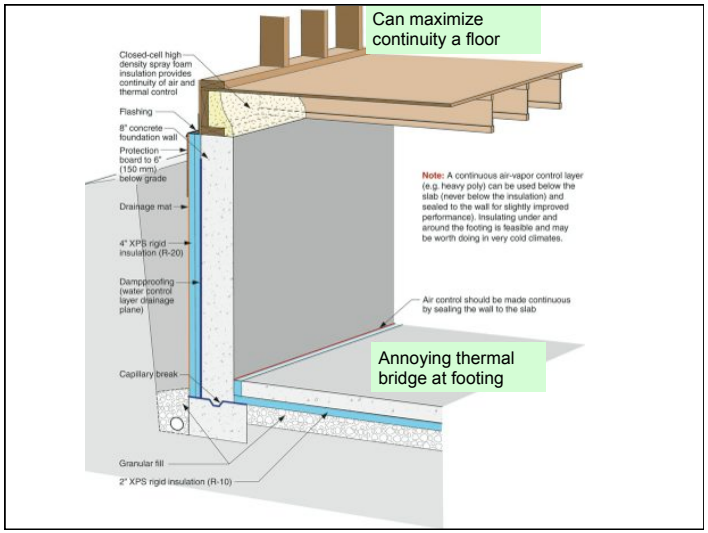
Basement Wall-Slab

- Continuity of air-thermal barrier a challenge at slab
- Continuity at floor slab also!

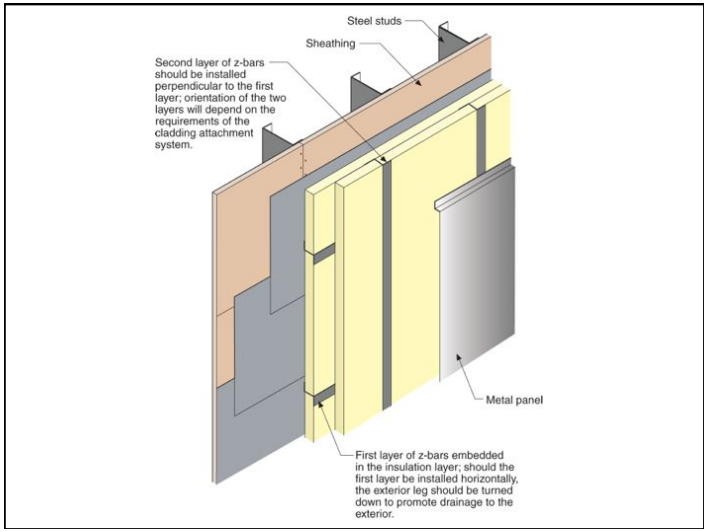

Insulation as drainage plane if lapped properly; as an air barrier if joints sealed (taped or caulked)
Polymer modified (PM) or standard Portland cement stucco with water repellent finish or elastomeric coating
Masonry wall (split-faced concrete block, tilt-up and solid precast concrete similar)
Concrete block starts below top of interior concrete slab
Weep screed
Concrete grade beam
Ground slopes away from wall at 5% (6 in. per 10 ft.)
Rigid insulation—expanded polystyrene, extruded polystyrene, polyisocyanurate, or spray polyurethane
Uninsulated steel stud
Gypsum board finish and fire control
Latex paint or other permeable or vapor semi-permeable interior finish
Sealant to provide air barrier continuity
Concrete slab
Granular capillary break and drainage pad (no fines)
Concrete footing below frost depth

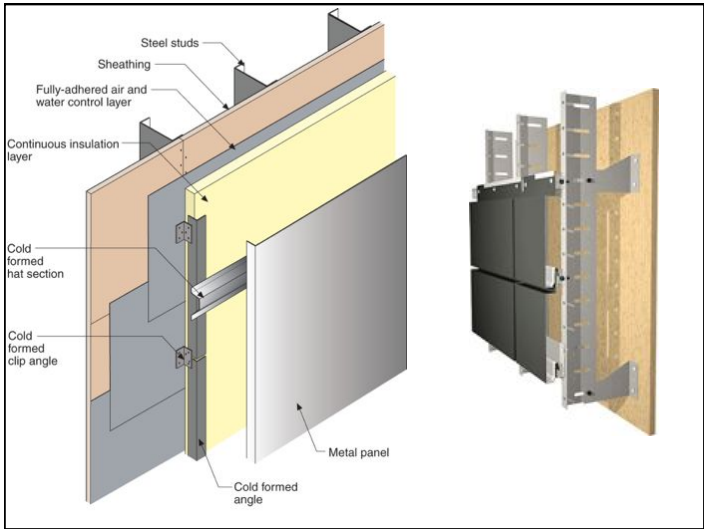

Closed-cell high density insulation provides continuity of air and thermal control
8" concrete foundation wall
Drainage mat
Dampproofing
Capillary break
Granular fill
2" XPS rigid insulation (R-10)
½" gypsum board ceiling
2" XPS rigid insulation (R-10) installed as continuous layer
2x6 wall with unfaced fiberglass insulation (R-19)
½" gypsum board with latex paint as vapor retarder

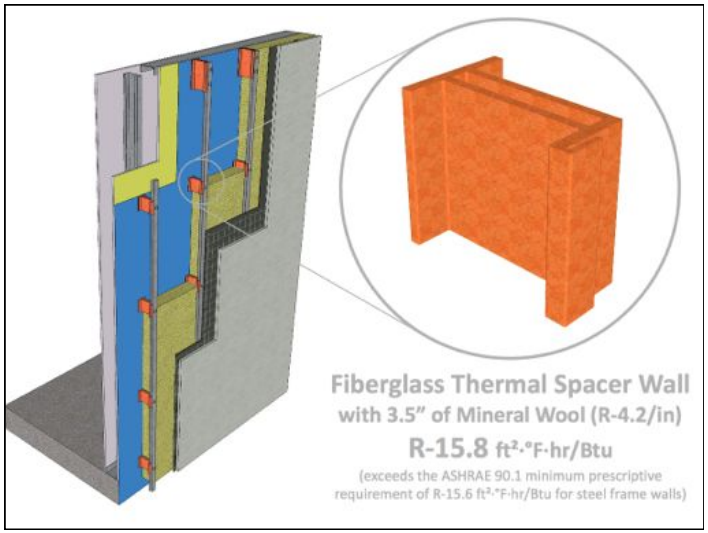


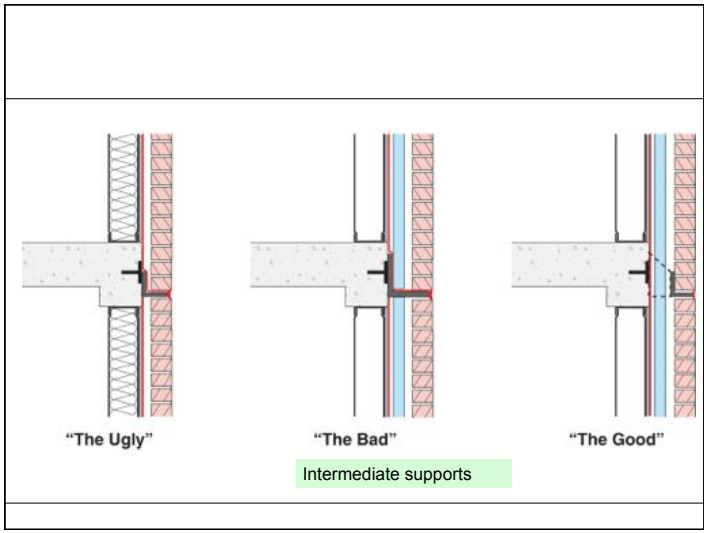

Can maximize continuity a floor
Closed-cell high density spray foam insulation provides continuity of air and thermal control
Flashing
8" concrete foundation wall
Protection board to 6" (150 mm) below grade
Drainage mat
4" XPS rigid insulation (R-20)
Dampproofing (water control layer drainage plane)
Capillary break
Granular fill
2" XPS rigid insulation (R-10)
Note: A continuous air-vapor control layer (e.g. heavy poly) can be used below the slab (never below the insulation) and sealed to the wall for slightly improved performance). Insulating under and around the footing is feasible and may be worth doing in very cold climates.
Air control should be made continuous by sealing the wall to the slab
Annoying thermal bridge at footing

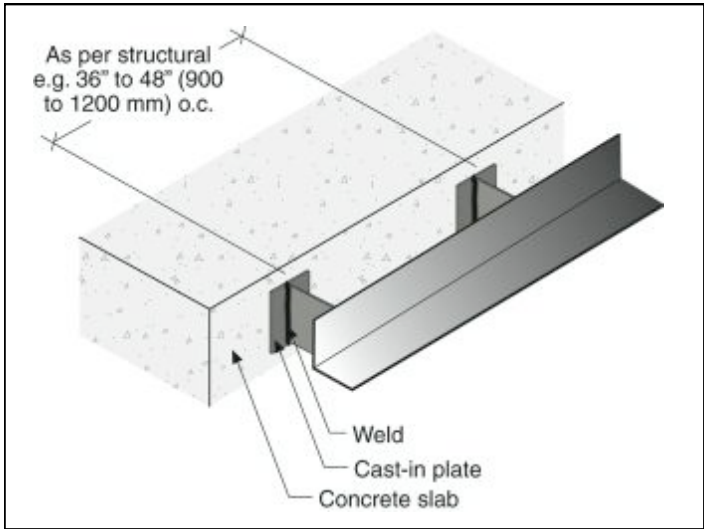
walls

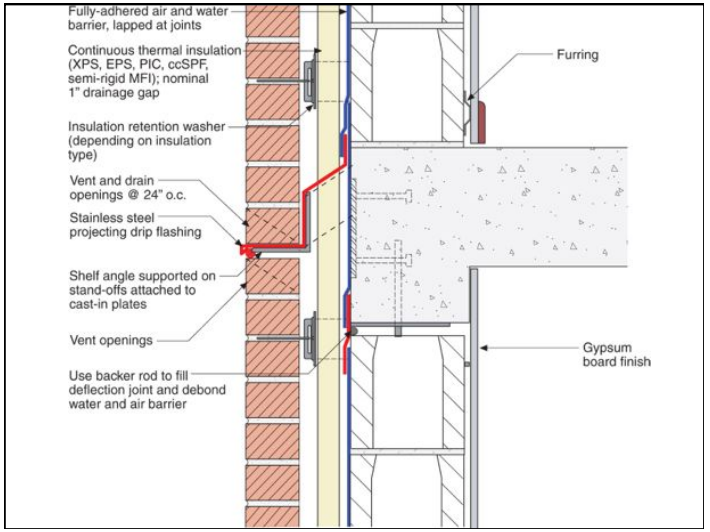

Steel studs
Sheathing
Second layer of z-bars should be installed perpendicular to the first layer; orientation of the two layers will depend on the requirements of the cladding attachment system.
Metal panel
First layer of z-bars embedded in the insulation layer; should the first layer be installed horizontally, the exterior leg should be turned down to promote drainage to the exterior.


Steel studs
Sheathing
Fully-adhered air and water control layer
Continuous insulation layer
Cold formed hat section
Cold formed clip angle
Metal panel
Cold formed angle

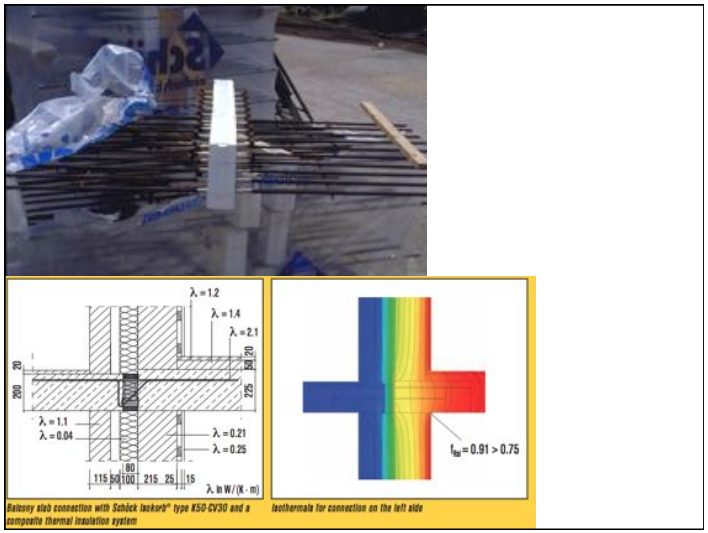

Fiberglass Thermal Spacer Wall
with 3.5" of Mineral Wool (R-4.2/in)
R-15.8 ft²·°F·hr/Btu
(exceeds the ASHRAE 90.1 minimum prescriptive requirement of R-15.6 ft²·°F·hr/Btu for steel frame walls)

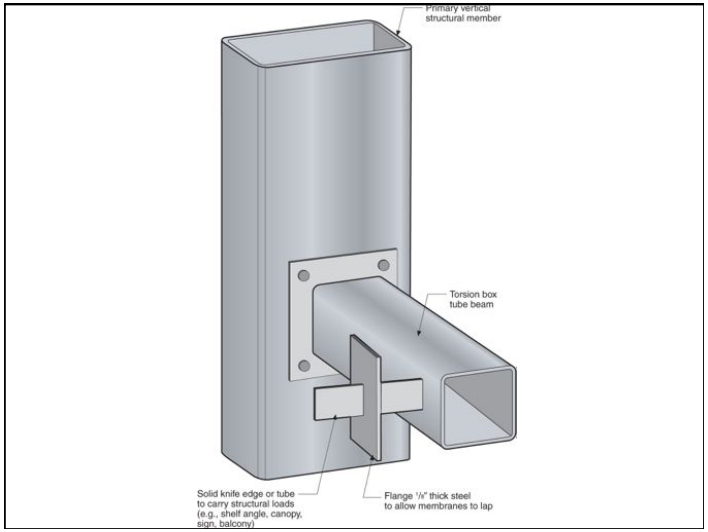

"The Ugly"
"The Bad"
"The Good"
Intermediate supports

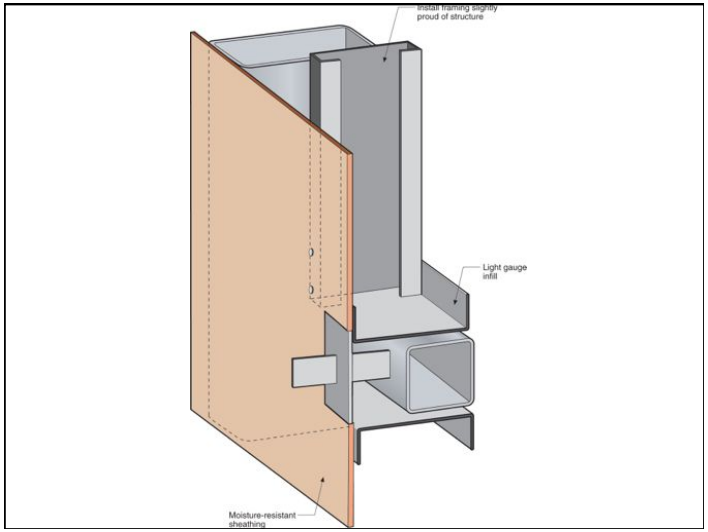

As per structural
e.g. 36" to 48" (900 to 1200 mm) o.c.
Weld
Cast-in plate
Concrete slab

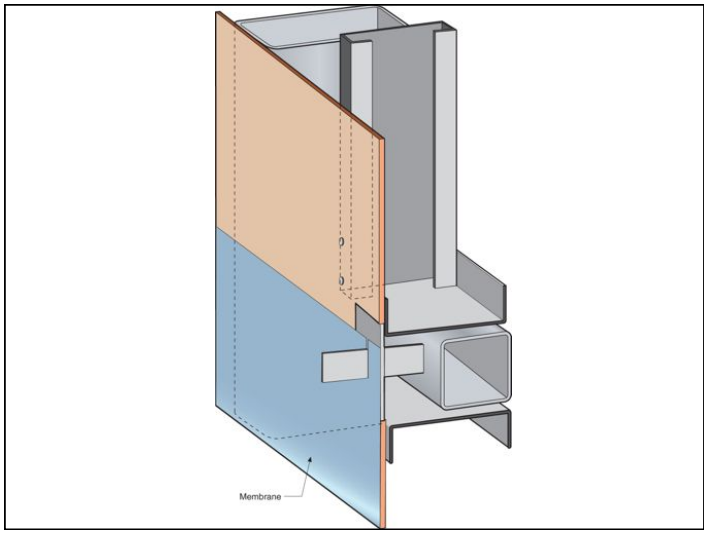

Fully-adhered air and water barrier, lapped at joints
Continuous thermal insulation (XPS, EPS, PIC, ccSPF, semi-rigid MFI); nominal 1" drainage gap
Insulation retention washer (depending on insulation type)
Vent and drain openings @ 24" o.c.
Stainless steel projecting drip flashing
Shelf angle supported on stand-offs attached to cast-in plates
Vent openings
Use backer rod to fill deflection joint and debond water and air barrier
Furring
Gypsum board finish

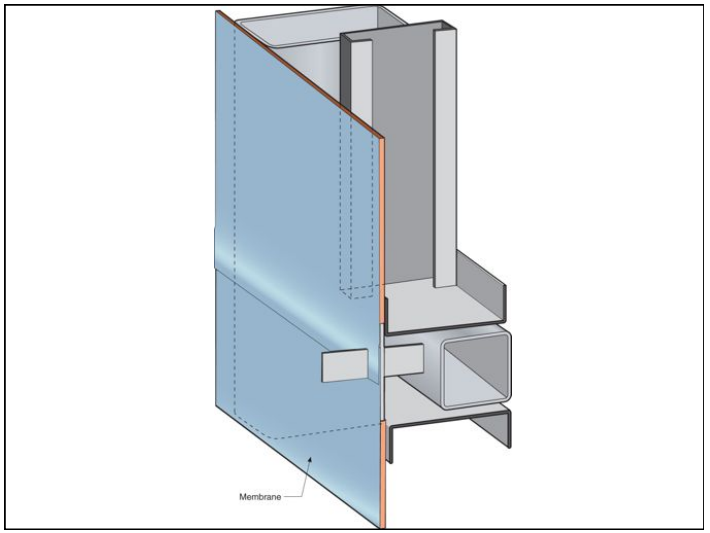
Small metal clips
dramatically reduce
thermal bridging


Balcony slab connection with Schöck Isokorb® type KS0-CV30 and a composite thermal insulation system
Isothermals for connection on the left side


Primary vertical structural member
Torsion box tube beam
Solid knife edge or tube to carry structural loads (e.g., shelf angle, canopy, sign, balcony)
Flange ⅛" thick steel to allow membranes to lap


Install framing slightly proud of structure
Light gauge infill
Moisture-resistant sheathing





Rigid Exterior Air Barrier

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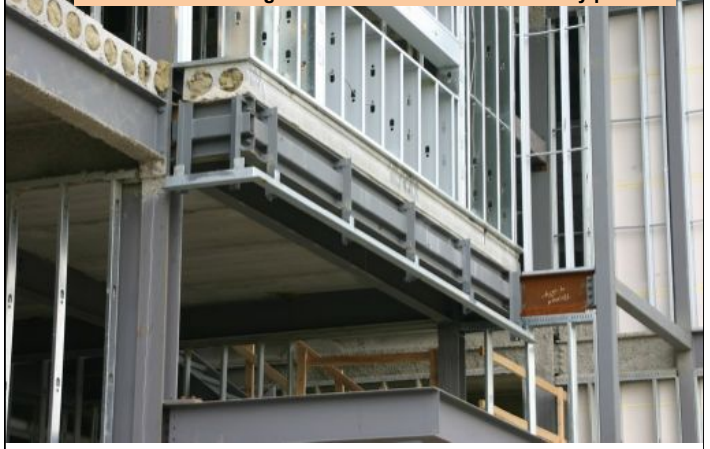
Commercial Buildings: Often exterior air barrier is only practical so



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